LPS 31: Introduction to Inductive Logic

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1 Description

Perhaps all knowledge of the natural world is arrived at by inductive inference. The predictions of our best scientific theories, medical diagnoses of pressing illnesses, and judgments about matters political and economic importance are all varieties of inductive inference. As should be plain, not all inductive inferences are equally good. Inductive logic is the study of rules of good inductive inference.

This course introduces students to the fundamentals of inductive logic, historical and philosophical puzzles of induction, as well as modern developments. In order to develop skills in formulating and analyzing arguments, students will first be introduced to the basics of deductive logic. We will then look at inductive arguments and various pitfalls humans fall into when reasoning inductively. This will lead us to seek out ways we might avoid such pitfalls and to investigate probability theory as a model for how to reason inductively. Classical philosophical problems (e.g. the Problem of Induction, the interpretation of probability, various probabilistic puzzles) will be explored along the way while students are equipped with tools they can use to improve their critical thinking and probabilistic reasoning in everyday contexts.

2 Learning Objectives

By the end of this course, students will be equipped to:

1. Formulate and analyze arguments via propositional logic and probability theory.
2. Identify cognitive biases that commonly afflict human inductive reasoning.
3. Correct for these biases by applying Bayes' Rule and other principles of probability to assess the quality of inductive arguments.

3 Course Materials

There is no required textbook for this course. All readings and exercises will be made available online via CANVAS.

However, I will draw from several textbook sources. Any of these texts may prove helpful resources for students interested in diving deeper into the subject. These sources are:

- *Choice and Chance: An Introduction to Inductive Logic* (4th edition) by Brian Skyrms, 2000, Wadsworth. (This text will be made available on CANVAS.)
- *An Introduction to Probability and Inductive Logic* by Ian Hacking, 2001, Cambridge University Press.
- *Superforecasting: The Art and Science of Prediction* by Philip Tetlock and Dan Gardner, 2015, Broadway Books. (This is a popular level text that covers probabilistic prediction at an informal level.)

4 Course Structure

This course will be taught entirely online. Each week, I will release pre-recorded, short **video lectures** to the CANVAS site, each covering a different topic. I will also release a simple but mandatory participation poll accompanying each lecture video.

Filling out **participation quizzes** that accompany the video lectures by their weekly due date (the due dates will be listed on each poll) is the way to earn

participation points in the course. You should watch the lecture videos before attempting the questions. You may, of course, return to re-watch the lecture videos as needed.

In addition, there are **weekly homework assignments** where you will get practice applying some of the concepts we cover together in the video lectures. These will typically be due at the end of each week (Fridays by 11:59 PT), and *should be submitted via Gradescope*. Late homework will not be accepted. However, your lowest homework grade will be dropped.

There will also be **two exams**: a midterm and a final. The final will *not* be cumulative. However, the concepts in this class build upon one another, so it will be important that you understand the material from early in the class in order to understand the material from later in the course.

All exams will be made available on the CANVAS site at 9am (PT) on exam day. You will have all day to complete the exams and upload them back onto Gradescope (so they will be due by 11:59 pm [PT] that day). Late exams will not be accepted. However, if you need to miss a test for a serious reason, please do reach out to me. In such a case, you must provide documentation (e.g. a medical note) in order to take a make-up exam on a different day.

Feel free to use any notes or books during both the exams and homework assignments. You may also discuss problems together, though every student must write/type out their own exam/homework.

In place of discussion sections, both your TAs and I will hold '**student hours**' over Zoom at various times during the week. You are encouraged to attend any of these student hours that you like. In these student hours, TAs will go over the past week's homework assignment and may review students' submitted answers.

My student hours will also be held over Zoom. You are encouraged to come to these virtual student hours and ask any questions you may have about lectures, homework, upcoming exams, and the course forecasting project! Please feel free to reach out to me or the TAs at any time.

5 Forecasting Project

Inductive reasoning involves estimating the likelihood of uncertain events on the basis of one's current knowledge. One theme of this course will be that there are better and worse ways to go about doing this, and that we, as humans, have a striking history of over-estimating our understanding of the world.

To give ourselves some practice employing sound methods of inductive reasoning, we will engage in forecasting project throughout the duration of our course in which we will make predictions about several real-world events and update our predictions as we go along. The details of this project can be found in a separate document uploaded to CANVAS.

For the project, you will be asked to assign a probability to several future events whose truth will become public knowledge sometime in the second half of the course. Your initial probabilities will be due by the end of Week 2 and you should feel free to do as little or as much research as you wish before assigning your probabilities.

You will be then given an opportunity to revise these probabilities and submit knew ones just before Week 4, 6, and 8. At the end of the quarter, the accuracy of your final probabilistic predictions will be measured by the Brier score (explained in the full project description) and your performance will be compared to both the class average and to the accuracy of your initial estimates.

A 2-3 page summary of your reasoning in forming your forecasts will be due at the end of finals week. You will be graded on completing the assignment and on the quality of your write up, not on the accuracy of your predictions. However, you can receive extra credit for the accuracy and calibration of your predictions.

6 Grading Breakdown

- **Participation** (20%). You earn points for participation by completing the participation quizzes that accompany slide video lectures by their listed due dates.
- **Homework** (20%). You earn points for homework by completing weekly assignments by Friday at 11:59 pm PT each week.

- **Forecasting Project** (20%). You earn points for the forecasting project by submitting bi-weekly forecast reports, along with producing a final report at the end of the session.
- **Midterm Exam** (20%). Roughly halfway through the course, we will have a midterm exam that covers the material up to that point.
- **Final Exam** (20%). At the end of the course, we will have a non-cumulative final exam covering material from the second half of the course.

7 Grade Scale

A: 90–100	B: 80–89	C: 70–79	D: 60–69	F: < 60

8 How to Succeed in this Course

Learning inductive logic is much like learning any new language. It is not enough to grasp the grammar of the language in the abstract—you have to 'speak' the language through repeated use and practice. You want to become fluent in inductive logic. To this end, the weekly assignments are meant to practice and develop fluency with the concepts learned in class.

Moreover, it has been thoroughly demonstrated that the most effective way of learning is teaching. You are free to collaborate with others on all of the homework, though you must write up your own work individually. I encourage students to engage one another in study groups and practice explaining your understandings to your classmates (and indeed to anyone who listens)!

Watch the video lectures, answer the participation polls on time, complete the weekly assignments, engage fully in the course forecasting project and you will do absolutely fantastic in the class (with probability close to one)!

9 Academic Integrity

I will trust you to be adults. This means you will uphold your responsibilities to adhere to the UCI Academic Integrity Policy. The policy is detailed here: `https://aisc.uci.edu/students/academic-integrity/index.php`. If you have any questions or uncertainty about the policy, you are responsible for meeting with me to discuss the policy to make sure you understand it clearly and completely.

10 Disabilities

Please notify me in advance of the need for accommodation of a University verified disability. I will make sure the appropriate accommodations are made. If you have any questions or concerns about disability accommodations, please don't hesitate to speak with me; I am very happy to help out!

11 How to Contact the Instructor or TAs

Contacting either the instructor or TAs in a course can be intimidating. So, below is a template and some tips for how to best and to do this.

First, a few preliminaries. The best way to contact the instructor or TAs for this course will be via email. The emails can be found on the syllabus. It is best to expect 48 hours to elapse for a reply. This is important: it means you should not expect to email the instructor or a TA the night before an exam or assignment and get a reply in time!

Importantly, before you contact the instructor or TA, do check the syllabus and course site to see if you cannot easily answer the question for yourself. If you still have a question after having checked the syllabus and/or the relevant portions of the course site, include in your email that you checked the syllabus and/or course site for the answer. Your instructor and TA will appreciate this and know that they can trust you not to be asking frivolous questions.

This might seem simple, but be polite and considerate. That is, in your message it is good to acknowledge that the other person is more than a machine for answering your questions! For example, a friendly greeting like, "I hope this finds you well," can go a long way in building rapport.

Finally, try to be clear and concise in your questions. The clearer your questions, the more effectively the instructor or TA can be in helping you. For example, "I don't understand homework 3" is far too vague. What, specifically, does the student not understand? Instead, a question like, "In problem 2 of homework 3, I am unclear if the question asking us to find the probability of event X or the probability of event Y?" is much more likely to get a helpful answer!

Here is a template to help you in writing your emails.

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Dear Instructor Mohseni,
I hope this finds you well.
I am writing to you to ask a question regarding homework 2.
(I have checked the course Canvas site and did not find the
answer to this particular question.)
My question is:  ...
Sincerely,
Nima
```

12 Course Schedule

The course outline is tentative and might be changed a bit as we go along. However, at the beginning of each week (on Mondays at 9:00 am PT), I will post the lectures, participation polls, and homework along with their deadlines for that week.

Week 1. Introduction. We introduce the course topic, review the syllabus, explore the course site, and begin our journey into inductive logic. We begin with an introduction to logic, and to the different sorts of conclusions produced by each deductive and inductive arguments (i.e., certain vs. uncertain), the different standards for inference each brings to bear (i.e., validity vs. inductive strength), as well as their characteristic domains of application (i.e., relationships of ideas vs. empirical matters of fact).

Week 2. Some Basic Propositional Logic. This week, we equip ourselves with the basics of propositional logic required for probability theory. In particular, we look at the logical expressions 'not', 'and', and 'or'; learning to translate between English and propositional logic; get acquainted with truth tables; and proceed to use truth tables to identify valid inferences along with tautological, contradictory, and contingent propositions.

Week 3. Philosophical Problems of Induction. Now, we explore historical, philosophical problems for the prospects of a logic of induction. In particular, we examine David Hume's classical problem of induction, and Nelson Goodman's new riddle for induction, and consider their implications for inductive inference.

Week 4. Probability Theory: Axioms, Definitions & Propositions. This week, we examine the axioms for probability theory, establish some basic propositions of probability theory, and introduce the definitions of mutual exclusivity of events, independence, and conditional probability.

Midterm Exam.

Week 5. Interpretations of Probability. Now, we consider prominent interpretations of probabilities. Specifically, we consider arguments for limiting frequency, propensity, and credential interpretations of probabilities. For the

credential interpretation, we introduce the connection between credences and betting odds.

Week 6. Biases in Inductive Reasoning and their Correctives. This week, we explore biases that tend to undermine our inductive reasoning and how to correct them using probability theory. The biases we consider are the availability heuristic, confirmation bias, base rate neglect, and the conjunction fallacy. As correctives, we use the principle of conservation of evidence, Bayes' rule, and other principles from the probability calculus.

Week 7. Justifications of Probabilism and Bayesian Learning. This week, we explore how Bayesian learning provides a partial answer to the Old and New Problems of Induction, and consider the Dutch book and accuracy-dominance arguments for why rational degrees of beliefs, at a time, should conform to the axioms of probability theory, and why rational learning, across time, should proceed via Bayes' rule.

Week 7. Further Principles of Rational Belief and Learning. This week, we consider some useful principles of rational judgment from Bayesian theory. Specifically, we look at the principles of total evidence, conservation of evidence, the principal principle, and the law of total probability.

Week 9. Philosophical Problems of Causation and Modern Advances We conclude by considering further applications of the Bayesian framework to better understand rational decision making, classical statistics, and scientific findings.

Week 10. Applications We conclude by considering further applications of the Bayesian framework to understanding the replication crisis in the social and biomedical sciences. We practice

Final Exam.

Week 11. Final forecasting reports due.